Research Article

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Long-term evaluation of indigenous coconut (*Cocos nucifera* L.) genotypes for yield and quality traits in Tamil Nadu

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Abstract

An investigation was carried out at Coconut Research Station, Tamil Nadu Agricultural University, Aliyar Nagar, Coimbatore, Tamil Nadu during 2008 – 2024 under ICAR – AICRP (plantation crops) scheme to evaluate coconut genotypes for growth and yield parameters. It involved ten locally collected tall genotypes from various places of Tamil Nadu (IC No. IC 610370, 610371, 610372,610373,610374,610375, 610376, 610377, 610378 and 610379). 'West Coast Tall' coconut served as standard check. The design followed was Randomized Block Design with three replications. Seedlings were planted during 2008 at a spacing of 7.5 X 7.5 m. and evaluated for sixteen years. The palms were maintained as per the recommended cultivation practices. At the end of sixteen years, all the parameters exhibited significant variations. Among the ten genotypes, IC 610371 [Madhusudhanapuram, Kanyakumari (Dt.)] recorded highest number of leaf scars in 1m length (11.7), leaf production per year (11.9), no. of functional leaves (32.8),leaf length (5.81 m), maximum no. of inflorescence/year (11.9), no. of spike lets/ inflorescence (35.3), no. of female flowers/palm/year (392), highest fruit set (36.61 %), maximum nut yield / palm/ year (138.6), husked fruit weight (649 g), kernel weight (357 g/nut), copra weight (153 g/nut), estimated copra yield/palm/year (21.20 kg), estimated copra yield per haper year (3.71 t) and tender nut water (520 ml per nut). The check variety 'West Coast Tall' registered lowest values for most of the above parameters. It witnessed the lowest yield of 95.5 nuts per palm per year. Due to higher nut yield and copra content, the genotype IC 610371 was identified as suitable for cultivation in Tamil Nadu.

Keywords: Coconut, genotype, nut yield, fruit parameters.

Introduction

Coconut (*Cocos nucifera* L.) is an important plantation crop in the world and it is cultivated in over 90 countries across tropical and subtropical regions.It is referred to as '*Kalpavriksha'* – the 'tree of heaven' as each and every part of the palm is useful in one way or the otherranging from food and beverage (coconut water, milk, oil, and meat) to materials for fiber, construction and biofuel.Ten million people in India depend on coconut for their livelihood either directly or indirectly. In India, it is cultivated in an area of 21,65,200 hectares with a production of 21373.62 million nuts having the productivity of 9,871 nuts per hectare. India ranks third in area and production in the world. Karnataka, Tamil Nadu, Kerala and Andhra Pradesh are the leading coconut producing states in India and they together account for more than 90 per cent of the total coconut produced in the country. Tamil Nadu ranks third in area (4,92,610 hectares) and second in production (6,091.98 million coconut nuts). In Tamil Nadu, the major districts are Coimbatore, Tirupur, Thanjavur, Dindigul and Kanyakumari. Coimbatore district occupies a major area of 93,226hain Tamil Nadu (Coconut Development Board, 2023-24). In any crop improvement programme,collection, conservation, and utilization of plant genetic resources and their distribution are indispensable components (Upadhyaya *et al*., 2008). Two major types of coconut exist, namely tall and dwarf. Tall varieties are predominantly cross-pollinated, whereas self-pollination accounts for the majority of

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reproduction in dwarf varieties. The cross-pollinated nature of tall coconuts contributes to greater genetic variability, which is a valuable attribute in germplasm collections for the selection of desirable genotypes in crop improvement programs. Germplasm resources form the foundation for the development of new varieties and the breeding of superior hybrids. They serve as a vital source of genetic diversity, enabling innovation and supporting the advancement of crop improvement efforts (Zhang *et al*., 2021). Continuous cultivation in a particularenvironment for a lengthened period also contributes to variability, because the performance of these genotypes is influenced by genotype x environmental interactions and can vary under different agro-climatic conditions (Ramanandam *et al*., 2018). Collection and conservation have to be focused to protect the genetic diversity of coconut palms. New genotypes are being introduced to assess their performance in particular locations for enhancing the coconut yield (Nath *et al*., 2017). Due to the perennial nature of coconut, assessing the performance and adaptability of new collections and release as a variety is a long term process. Coconut Research Station, Aliyarnagar is maintaining valuable germplasm in coconut. Hence, the present investigation was undertaken to evaluate the performance of indigenous coconut germplasm for yield and quality and to identify the promising genotypes suitable for Tamil Nadu.

Materials and methods

The present study was conducted at the Coconut Research Station, Tamil Nadu Agricultural University, Aliyarnagar, located near the Western Ghats in Coimbatore district, Tamil Nadu. The station is situated in the western zone of Tamil Nadu at 10.50° N latitude and 76.98° E longitude, at an elevation of 300 m above mean sea level. The trial was conducted under the scheme ICAR-AICRP on Plantation Crops functioning at Central Plantation Crops Research Institute, ICAR, Kasaragod, Kerala. The region receives a total rainfall of 802 mm in a year, with nearly 300 mm of precipitation witnessed during the Southwest monsoon (37 %), 333 mm during North East monsoon (42 %) and 169 mm during summer (21 %). The maximum and minimum temperatures during summer are 35°C and 22.1°C respectively. The maximum and minimum winter temperatures are 31.9°C and 16.8°C respectively. Average relative humidity is 75 – 83 % (Morning 87 % and afternoon 57 %). The soil type is sandy clay loam and non-calcareous with a pH of 7-7.5, EC 0.5 ds/m. The soil nutrient status is low in available nitrogen and medium in available phosphorus and potassium. The seed materials comprised of ten tall coconut genotypes collected within Tamil Nadu along withone check (West Coast Tall) (Table 1).

Table 1. Details of genotypes

S. No.	Accession number	Source of collection
1	IC 610370	Thathur, Coimbatore (Dt.)
2	IC 610371	Madhusudhanapuram, Kanyakumari (Dt.)
3	IC 610372	Ethamozhi, Kanyakumari (Dt.)
4	IC 610373	Ethamozhi (garden land and semidry), Kanyakumari (Dt.)
5	IC 610374	Ethamozhi, Kanyakumari (Dt.)
6	IC 610375	Vairakudiyiruppu Kanyakumari (Dt.)
7	IC 610376	Aliyarnagar, Coimbatore (Dt.)
8	IC 610377	CRS, Aliyarnagar, Coimbatore (Dt.)
9	IC 610378	Hanumandhampatti,Theni (Dt.)
10	IC 610379	Coimbatore
11	-	West Coast Tall (check)

The genotypes were planted duringJuly 2008 at a spacing of 7.5 × 7.5 m. The statistical design followed was Randomized Block Design with three replications. For each genotype, four palms were maintained per replication. The palms were maintained under irrigated condition and recommended agronomic practices were followed for all the genotypes.

Observations were recorded for vegetative, flower and fruit component traits as per the standard descriptors (Ratnambal *et al*., 1995).Every year after planting, observations were recorded for all the above parameters. The palms were tested for yield stability after ten years of planting and examined for five years (July 2018 – June 2023).After achieving satisfactory yield stability, observations were recorded during the period from July 2023 to June 2024. The results presented in this study pertain to the yield stabilization phase and are expressed as the mean of four palms per genotype in each replication.

Traits like stem height (m), stem girth at 1 m (cm), leaf scars in 1m length, no. of functional leaves and leaf length (cm) for the period July 2023 – June 24 were measured during July 2024 for all the four palms per genotype per replication and the mean was calculated.

mean was calculated.Statistical analysis was done as per GRAPES software.

Results and Discussion

Analysis of variance for growth and yield characters are given in Tables 2 and 3

Table 2. Analysis of variance for growth characters and yield traits

Traits/ Parameters	ST (m)	SG (cm)	LS	LP	NFL	LL (m)	NIY	NSI	NBI	NFPY
Mean squares (genotypes)	2.410	23.32	1.628	0.411	7.071	0.156	0.271	15.916	8.648	79.124
Mean squares (error)	0.044	0.970	0.077	0.095	0.661	0.017	0.142	2.851	0.347	3.681
F ratio	55.291**	24.041**	21.037**	4.316**	10.699**	9.325**	2.614**	13.725**	9.830**	21.494*
Probability	0.000	0.000	0.000	0.003	0.000	0.000	0.032	0.000	0.000	0.000

** - significant at 5%

ST-Stem height, SG-Stem Girth, LS-Leaf Scars, LP-Leaf Production, NFL-No. of Functional Leaves, LL- Leaf Length, NIY- No. of Inflorescence/year, NSI-No. of Spikelets/Inforesence, NBI-No. of Buttons/Inflorescence, NFPY-No. of Female Flowers per Palm per Year

Table 3. Analysis of variance for additional growth characters and yield traits

Traits/ Prameters	FS (%)	NNPY	FW (g)	HFW (g)	KW (g/nut)	CW (g/nut)	ECY (kg/ha)	ECY (t/ha)	TNW (ml)
Mean squares(genotypes)	16.924	24.677	149.265	126.147	71.326	31.018	15.740	0.482	25.651
Mean squares (error)	0.968	1.212	7.897	5.786	4.582	2.274	0.191	0.007	2.498
F ratio	17.474**	22.835**	18.901**	21.863**	15.567**	13.640**	65.982**	72.553**	10.269**
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

FS- Fruit Set, NNPY- No. of Nuts/Palm/Year, FW- Fruit Weight , HFW – Husked Fruit Weight, KW- Kernel Weight, CW – Copra Weight, ECY – Estimated Copra Yield, TNW- Tender Nut Water
Table 'F' value at P = 0.05 for df *(10, 2) = 2.086
*Where 10 = df due to genotypes and 2 = df due to error

Parameters likeno. of spike lets/ inflorescence, no. of buttons/inflorescence, fruit weight (g), husked fruit weight (g), kernel weight (g), copra weight (g/nut)and tender nut water (ml) were recorded from five inflorescences/palm/year for flower traits and five harvests/ palm/year for fruit characters for the period July 2023 – June 2024. Tender nuts were harvested at 7 months after spathe opening and the quantity of water was recorded. These were recorded from three palms per genotype at the rate ofone palm per replication and the mean was calculated.For each harvest, four nuts were selected per genotype per replication.

Observations like leaf production per year, no of inflorescence /year, no. of female flowers/palm/year, fruit set(%), nut yield / palm/ year, estimated copra yield/palm/year(kg) and estimated copra yield/ha/year (t)were also recordedfor the period July 2023 – June 2024for all the four palms per genotype per replication and the

Growth characters

Significant variations were noticed for the growth characters (Table 4). At the age of 16 years, IC 610378 recorded highest stem height of 9.1 m and stem girth at 1 m height (119.4 cm).Among the genotypes, IC 610371 recorded highest number of leaf scars in 1m length (11.7), leaf production per year (11.9), no. of functional leaves (32.8) and leaf length (5.81 m) whereas the check variety West Coast Tall registered the lowest values for leaf production per year (10.6), no. of functional leaves (28.1) and leaf length (5.07 m).

Annual leaf production, no. of leaves and leaf length are important characteristics since they determine the leaf's capacity to support bunches in the axis and promote the photosynthetic efficiency (Mohanalakshmi *et al*., 2023). Coconut palms characterized with a circular crown, strong petiole, retaining maximum functional leaves and inflorescence with high number of female flowers are desirable for selection and hybridization programmes (Sivakumar *et al*., 2022).

Table 4. Growth characteristics of coconut genotypes at 16 years of age

IC number	Stem height (m)	Stem girth at 1 m (cm)	No. of leaf scars in 1m length	Leaf production per year	No. of functional leaves	Leaf length (m)
610370	5.75	99.2	9.8	11.6	30.6	5.55
610371	7.58	118.6	11.7	11.9	32.8	5.81
610372	8.85	109.2	10.6	11.2	30.4	5.56
610373	7.83	99.00	9.6	11.1	29.2	5.36
610374	8.18	115.2	11.2	11.5	29.2	5.10
610375	8.04	110.4	11.5	11.7	31.4	5.34
610376	7.34	96.6	11.0	11.8	31.6	5.70
610377	7.54	100.0	10.8	11.4	31.8	5.33
610378	9.10	119.4	11.5	11.2	31.0	5.44
610379	8.41	103.0	11.6	11.3	28.2	5.33
WCT	8.30	106.6	10.2	10.6	28.1	5.07
Mean	14.48	107.01	10.86	11.39	30.39	5.41
SE (d)	0.19	1.85	0.24	0.21	0.54	0.13
CD (5%)	0.40	3.76	0.50	0.43	1.10	0.27

Floral characters

The floral traits exhibited significant variations (Table 5). Among the genotypes studied, IC 610371 registered maximum no. of inflorescence/year (11.9), no. of spike lets/ inflorescence (35.3) and no. of female flowers/palm/year (392) whereas WCT witnessed lowest values of 10.6, 27.5, and 310 respectively.

Among the ten genotypes, IC 610371 registered maximum no. of nuts / palm/ year (138.6) where as WCT registered lowest values (95.5). Abeywardena and Mathew (1980) stressed that, due emphasis should be given to number of nuts per bunch in the selection programme, as it leads to an increase in the production of the number of nuts per palm.

Table 5. Floral characteristics and nut yield of coconut genotypes at 16 years of age

IC number	No of inflorescence /year	No. of spikelets/ inflorescence	No. of buttons/ inflorescence	No. of female flowers/ palm/year	Fruit set (%)
610370	11.0	28.2	31.3	344	33.10
610371	11.9	35.3	33.2	392	36.61
610372	10.9	30.5	34.6	377	34.10
610373	10.8	33.5	31.5	340	35.80
610374	11.4	33.0	32.5	380	34.21
610375	10.8	31.1	33.8	365	35.10
610376	11.5	34.0	32.5	373	36.00
610377	11.1	32.5	29.5	326	31.30
610378	10.9	30.6	31.9	347	29.20
610379	11.2	30.2	30.5	341	32.50
WCT	10.6	27.5	29.2	310	30.80
Mean	11.1	31.49	31.86	354.09	33.52
SE (d)	0.19	0.60	0.57	9.13	0.67
CD (5%)	0.40	1.22	1.16	18.68	1.38

The highest no. of buttons/inflorescence was recordedin IC 610372 (34.6) and the lowest was found in WCT (29.2). The highest fruit set of 36.61 % was noticed in IC 610371 whereas the lowest was recorded in IC 610378 (29.20 %).

Yield parameters

Significant variations were recorded for yield parameters (Table 6). In this study, different genotypes showed variable nut characters. Selvaraj and Maheswarappa, (2016)observedthat, the variation in nut characters might be due to both genetic and environment factors besides soil moisture and nutrient status.

A high rate of leaf production during the early growth phase of the tree is positively correlated with early flowering, nut yield and copra yield indicating the future yield potential of the hybrid (Liyanage *et al*., 1988).The highest number of nut yields observed in IC 610371 might be due to the increased number of functional leaves and inflorescences per palm and these might have

contributed for higher photosynthetic accumulation towards the reproductive phase (Praneetha *et al* ., 2023). Nampoothiri *et al*. (1975) also reported that the number of leaves present on the crown was positively correlated with yield in coconut.Further, the increased number of leaves maximizes sunlight interception, total chlorophyll content, and the surface area for CO_2 absorption which ultimately increases the photosynthesis. This higher photosynthetic rate produces more biomass, which ultimately supports increased crop productivity. Because, the leaves (fronds) are the primary sites for carbohydrate production through photosynthesis that fuel the fruit development.

Among the ten genotypes, IC 610371 registered maximum husked fruit weight (649 g) and kernel weight (357 g/nut). Fruit weight was maximum in IC 610370 (1622g) and it was followed by IC 610371 (1616 g). The lowest values for husked fruit weight (478 g), kernel weight (252 g) and fruit weight (940 g) were recorded by IC 610379. Rachel *et al. (*2010) detailed that the kernel weight is positively correlated with the husked fruit weight.

IC 610371 registered maximum copra weight (153 g/nut), estimated copra yield/palm/year (21.20 kg) and estimated copra yield/ha/year (3.71 t) among the ten genotypes. The lowest value for copra weight (131 g) was recorded by IC 610379. WCT registered lowest values for estimated copra yield/palm/year (13.64 kg) and estimated copra yield/ha/year (2.39 t) due to lowest number of nuts per palm. A wide range of variation for oil and copra content was reported in different countries and it depends upon the stage of maturity and place of origin, etc., (Suchithra and Paramaguru, 2019). Ramanathan *et al*. (1992) and Patil *et al*. (1993) reported that husked fruit weight, kernel weight and shell weight were directly related to the copra content of a nut. In this study, IC 610371 registered maximum husked fruit weight and kernel weight and these might have contributed for increased copra content. Since IC 610371 has recorded maximum number of nuts per palm, the estimated copra yield was also highest making it suitable for cultivation and coconut-based processing industries.

In the selection of genotypes either for direct utilization as varieties or as parents in hybridization programmes, high nut yield, high copra content, and oil content are the significant parameters. Copra out turn is an important yield trait that is essential for sustaining coconut-based industries. The results of Bai and George (2002) in coconut revealed that, even though the total nut production can be considered as an important criterion in breeding programmes, the partitioning of total dry matter towards the economic yield in terms of copra content too serves as a basic selection parameter in judging the yield potential of the palms.

Eventhough tall coconut genotypes arefamous for culinary and oil extraction, it can be used for tender nut purposes also like the dwarf one. In this study, IC 610371 showed highest quantity of tender nut water (520 ml)indicating its use as a dual purpose variety whereas IC 610379 recorded only 137 ml of water.

Table 6. Yield parameters of coconut genotypes (at 16 years age)

IC number	No. of nuts/ palm/ year	Fruit weight (g)	Husked fruit weight (g)	Kernel weight (g/nut)	Copra weight (g/nut)	Estimated copra yield (kg/palm)	Estimated copra yield (t/ ha)	Tender nut water (ml)
610370	113.8	1622	642	351	142	16.16	2.83	169
610371	138.6	1616	649	357	153	21.20	3.71	520
610372	128.6	1551	614	321	147	18.90	3.31	334
610373	121.9	1599	620	315	135	16.45	2.88	212
610374	130.4	1400	581	284	141	18.38	3.22	148
610375	128.2	1556	590	290	136	17.44	3.05	205
610376	134.0	1218	623	311	132	17.63	3.09	213
610377	102.0	1568	595	322	146	14.93	2.61	220
610378	101.4	1550	634	332	140	14.20	2.49	184
610379	111.3	940	478	252	131	14.69	2.57	137
WCT	95.5	1244	565	282	142	13.64	2.39	280
Mean	118.7	1442.18	599.18	310.63	140.45	16.69	2.92	238.36
SE(d)	1.62	48.31	18.61	8.95	1.98	0.51	0.08	2.13
CD (5%)	3.26	98.74	38.24	18.2	4.02	1.05	0.18	4.28

Since IC 610371 performed well for growth and yield parameters, oil content was analyzed and compared with the check variety 'West Coast Tall. IC 610371 recorded 63.12 % oil content whereas WCT registered 66.80 %. But the estimated oil yield per palm per year and per hectare per year was highest in IC 610371 (30.93 kg and 2.32 tonnes respectively) due to the production of higher number of nuts per palm (138.6). The WCT recorded only 20.53 kg and 1.54 tonnes respectively due to the lesser number of nuts (95.5) (Table 7).

Table 7. Comparison of IC 610371 with WCT for oil content

S. No.	Characters	IC 610371	WCT
1	Oil content (%)	63.12	66.80
2	Estimated oil yield (kg/tree/year)	30.93	20.53
3	Estimated oil yield (tonnes/ ha/year)	2.32	1.54

The yield during yield stabilization phase for IC 610371 was recorded and is given in table 8.

The crown, bunch, whole fruit, CS and LS of nuts and husked fruit views of IC 610371 and kernel comparison of IC 610371 with WCT are depicted in plates 1-5.

Conclusion

Based on the superior performance of IC 610371 in terms of maximum no. of inflorescence, no. of female flowers/palm, highest fruit set, maximum no. of nuts, husked fruit weight, kernel weight, copra weight, estimated copra yield and tender nut water than other genotypes, it can be concluded that the above genotype is highly suitable for cultivation in Tamil Nadu (except hilly region). It recorded 45.13 % increased nut yield and 50.65 % higher oil yield per tree than the local check 'WCT'. The higher copra and oil yield makes it suitable for processing industries. In addition, it can be used as a parent in hybridization programme. During the XXXIV AICRP (Plantation crops) annual group meeting held during May 2025, IC 610371 was released as a variety in the name of 'ALR 4' (Aliyarnagar 4).

Table 8. Yield during yield stabilization phase

S. No.	Geno type	Age at first flowering (MAP)	Yield per palm per year (Nos.)						Average
			2018 -19	2019 -20	2020 -21	2021 -22	2022 -23	2023 -24	(6 years)
1	IC 610371	56	132.7	145.7	134.9	140.1	132.4	138.6	137.4

MAP- Months after planting

Characteristic features of IC-610371

Fig. 1. Crown view

Fig. 2. Fruit bunch

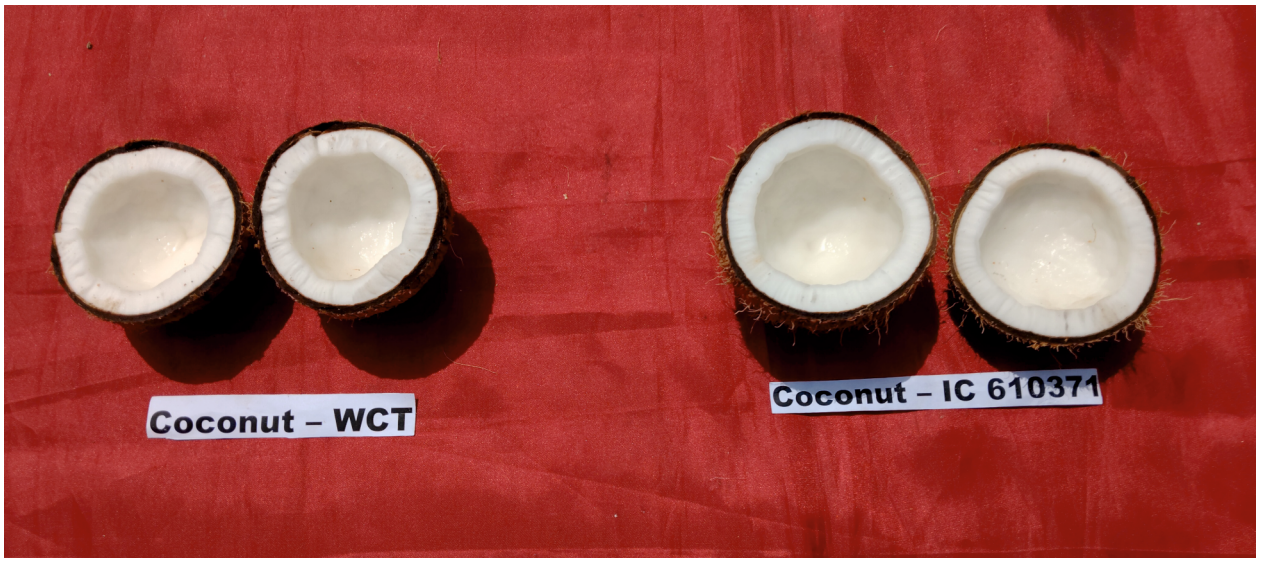

Fig. 3. Comparative features of IC 61.371 and WCT

Fig. 4. Weight of husked fruit

Fig. 5. Whole fruit, CS, LS

The DUS characters for IC 610371 are given below.

1.	**ACCESSION DATA**	
1.1	Cultivar name	Madhusudhanapuram Local (IC 610371)
1.2	Accepted abbreviation	MSP
1.3	Accession number	IC 610371
1.4	Country of collection/Source	India. Madhusudhanapuram village of Kanyakumari district, Tamil Nadu
1.5	Acquisition	2007 (Seed nuts were collected)
2.	**PLANT MORPHOLOGY**	
2.1	Age of measurement (years)	16
2.2	Category	Tall
2.3	Crown shape	Circular
2.4	Plant height (cm)	758
2.5	Girth of trunk at 1m height (cm)	118.60
2.6	Total number of leaves	36.40
2.7	Length of petiole (cm)	149.50
2.8	Length of leaflet bearing portion(cm)	431.50
2.9	Number of leaflets (right)	110.32
2.10	Number of leaflets (left)	113.26
2.11	Length of leaflet (cm)	134.41
2.12	Breadth of leaflet (cm)	5.20
2.13	Number of leaf scars in 1 m length	11.70
2.14	Length of 10 internodes (cm)	97.12
3.	**REPRODUCTIVE BIOLOGY**	
3.1	Pollination group	Cross pollination
3.2	Age at first flowering (months)	56 months
3.3	Length of inflorescence (cm)	103.00
3.4	Length of spikelet bearing portion (cm)	43.17
3.5	Length of stalk (cm)	60.28
3.6	Length of spikelet (cm)	48.21
3.7	Number of spikelets in inflorescence	35.3
3.8	Number of female flowers / inflorescence	33.2
3.9	Number of inflorescence / year	11.90
3.10	Length of male phase (days)	19.3
3.11	Length of female phase(days)	4.7
3.12	Gap between male and female phases(days)	2.73
3.13	Intraspadix overlapping (days)	Nil
3.14	Interspadix overlapping (days)	Nil
4.	**HARVEST DATA**	
4.1	Age of first harvest (Months)	67 months
4.2	Setting percentage	36.61
4.3	Number of nuts per year	137.40
4.4	Bearing habit	Regular
5.	**FRUIT CHARACTERS**	
5.1	Colour of fruit	Green
5.2	Shape of fruit	Oval
5.3	Length of fruit (cm)	23.80
5.4	Breadth of fruit (cm)	12.90
5.5	Weight of fruit (g)	1616
5.6	Thickness of husk (cm)	2.20
5.7	Husked fruit weight (g)	649
5.8	Percentage of husk to whole fruit wt.	59.84
5.9	Thickness of kernel (cm)	1.30
5.10	Weight of kernel (g)	357
5.11	Thickness of shell (cm)	0.30
5.12	Weight of shell (g)	207.12
5.13	Copra content (g/nut)	153
5.14	Copra/palm/year (kg)	21.20
5.15	Oil content (%)	63.12
5.16	Oil yield per ha (t)	2.32
6.	**BIOCHEMICAL TRAITS**	**BIOCHEMICAL TRAITS**
6.1	Leaf protein content (mg/g FW)	4.72
6.2	Leaf polyphenol content (mg/g FW)	8.06

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